REMARKS

The applicants appreciate the Examiner's thorough examination of the application and request reexamination and reconsideration of the application in view of the preceding amendments and following remarks.

The Examiner objects to the drawings filed April 5, 2002 for the reasons stated in the "Notice of Draftsperson's Patent Drawing Review" attached to Paper No. 3. In response, the applicants enclose herewith eleven (11) sheets of formal drawings.

The Examiner rejects claim 23 under 35 U.S.C. §112, first paragraph. The Examiner alleges that the specification fails to support the claimed range of values. The applicants respectfully disagree with the Examiner that the applicants' specification fails to support the range of values as recited in claim 23. The applicants' amended claim 23 now recites: "The apparatus of claim 1 wherein said mass determining device measures the change in mass of a substance in the range of about 100 picogram/mm^2 to 100,000 picogram/mm^2." As recited in the applicants' specification, page 12, lines 9-11 the claimed apparatus can detect mass change of 2×10^{-10} g/mm^2: "Using Equation (2), it can be determined that this frequency change of Δf corresponds to a mass change Δm of 2×10^{-10} g/mm^2, as shown in Fig. 5". Clearly, 2×10^{-10} g/mm^2 is the equivalent of 200×10^{-12} g/mm^2 which is 200 picogram/mm^2. 200 picogram/mm^2 is within the claimed range values 100 to 100,000 picogram/m^2. Therefore, the applicants' specification supports the claimed range of values as recited in claim 23.

Accordingly, claim 23 is clearly in accordance with 35 U.S.C. §112, first paragraph.

The Examiner rejects claim 23 under 35 U.S.C. §112, second paragraph as being

indefinite. The Examiner alleges that picogram/mm^2 is not a unit of mass but is rather mass/area (i.e., surface density). As shown above under AMENDMENT C, claim 23 now recites that claimed apparatus measures the change in mass. The units of picogram/mm^2 are clearly units to measure the change in mass as defined by Equations (1) and (2) as recited in the applicants' specification, page 11, line 8 – page 12, line 11. The relationship between mass change Δm and mass change is shown in Fig. 5. The mass sensitivity, S_m defines the relationship between mass and frequency change and is determined by Equation (1), as shown on page 11, line 14 of the applicants' specification. Once mass sensitivity S_m is known for a particular sensor, the mass of a substance placed on a membrane can be determined by Equation (2) (page 12, line 4 of the applicants' specification). Using Equation (2) the claimed apparatus can then determine that the frequency change Δf corresponds to the mass change Δm, which in one example was given as 2×10^{-10} g/mm^2.

Accordingly, when read in light of the specification and as amended herein, claim 23 defines units of the change of mass and is therefore definite and in accordance with 35 U.S.C. §112, second paragraph. Accordingly, the Examiner's rejection of claim 23 under 35 U.S.C. §112, second paragraph is to be withdrawn.

The Examiner rejects claims 1-3, 5, 7-8, 15, 17-18 and 22-23 under 35 U.S.C. §102(b) as being anticipated by White *et al.* in U.S. Patent No. 5,218,988. The Examiner alleges that White *et al.* discloses a sensor for measuring the mass of a substance on a membrane and refers to Col. 11, lines 61-68.

The truly effective and accurate apparatus and method for measuring the mass of a substance, as claimed by the applicants, includes the unique combination of a sensor

having a membrane layer which receives a substance thereon, an oscillator device configured to output a signal which drives the membrane at a reference resonant frequency, a frequency detection device configured to determine the change in the reference resonant frequency caused by the presence of the substance on the membrane, and a mass determining device configured to determine the mass of a substance wherein the amount of change in the reference resonant frequency is indicative of the mass of the substance. The unique apparatus and method as claimed by the applicant is capable of detecting mass changes of the sensor in the picogram range. See applicants' specification, page 12, lines 1-9.

Specifically, the apparatus for measuring the mass of a substance as claimed by the applicants in claim 1 includes: 1) a sensor having a membrane layer, the membrane for receiving the substance thereon; 2) an oscillator device configured to output a signal which drives said membrane at a reference resonant frequency; 3) a frequency detection device configured to determine a change in the reference resonant frequency caused by the presence of the substance on the membrane; and 4) a mass determining device configured to determine the mass of the substance wherein the amount of change in the reference resonant frequency is indicative of the mass of the substance.

In sharp contrast, White *et al.* does not teach, suggest, or disclose an oscillator device which is configured to output a signal to drive the membrane at a reference resonant frequency. Instead, White *et al.* teaches and discloses a Lamb-wave device which responds to changes of membrane tension, surface loading, and changes in transducer dimensions. White *et al.* clearly teaches, suggests, and discloses the use of Lamb-waves and makes a departure from the use of standing wave, i.e., SAWs or

Rayleigh waves: "This invention marks a departure from the use of SAWs or Rayleigh waves in ultrasonic sensors and employs instead Lamb-waves, which are also known as plate-mode waves. (Col. 3, lines 11-14.)

Lamb-waves are in stark difference to standing waves. As shown in *MEMS Reliability Assurance Guidelines for Space Applications*, Stark, Brian, JPL Publication 99-1 January 1999, Chapter Six, entitled "Common Device Elements", beginning on page 105, attached hereto as Exhibit A:

> Engineers also utilize waves on plates as transducers. There are two kinds of waves that travel in plates. They are dilation waves, which involve changes in volume without rotation, and distortion waves, which do not change volume but instead result in rotation and shearing of a given material. In more common terminology, the dilation wave is referred to as a longitudinal wave, while the distortion wave is often called a transverse or shear wave. These waves travel with a velocity that is material dependent and, the respective velocities of each, c_l...
>
> In plates, these two waves interact in complex ways at the plate boundaries, which results in the formation of a plate wave, which is also called a lamb wave. These waves travel in either symmetric or anti-symmetric modes as shown in Figure 6-10. The lowest order of these modes are very similar to surface acoustical waves, or SAW, that propagate along a semi-infinite medium. However, in thin plates, the lowest order symmetric mode is dispersionless and propagates much faster than a SAW on the same materials. The lowest order anti-symmetric mode, on the other hand, involves flexure and its wave velocity decreases monotonically to zero as the plate becomes infinitely thin.

As shown in Fig. 6-10, page 106 of Exhibit A, there is a distinct difference between the surface (Rayleigh) wave as shown in (c) and the symmetric and anti-symmetric wave Lamb-waves as shown in (d) of Fig. 6-10.

More proof that standing waves are distinctly different from Lamb-waves is found on page 108 of Exhibit A:

> While lamb waves have many applications in membranes, it is also useful to excite standing waves on plates. A standing wave, as opposed to a lamb wave, involves oscillations in fixed spots. These waves have maximum displacement at the resonant frequency of a device. On a resonating plate, there will be distinct

spots called nodes, where vertical motion is essentially zero, and spots called anti-nodes, where oscillations are maximized. (Emphasis added).

As shown in Fig. 3 of the applicants' specification, clearly the claimed oscillated device is configured to output a standing wave which drives the membrane at a reference resident frequency. As known to those skilled in the art, transducer 16 of the applicants claimed measurement apparatus is the equivalent of "a fixed spot and produces standing waves" as shown above. Accordingly, transducer 16 initiates the standing wave, not a Lamb wave.

Moreover, the oscillating device (e.g., oscillator 20, Fig. 1 of the applicants' specification) is connected to transducer 16 for driving the membrane at a reference resonant frequency. *See* applicants' specification, page 10, lines 8-9. In contrast, White *et al.* teaches that a force applied to the membrane strains the membrane and causes a change in oscillator frequency. See White *et al.*, Col. 11, lines 61-68. Driving the membrane at a reference resonant frequency is completely different than a membrane which receives a force which strains the membrane to cause a change in oscillator frequency.

For the reasons stated above, White *et al.* does not teach, suggest, or disclose each and every element of the applicants' claimed invention as recited in independent claim 1, namely an oscillator device configured to output a signal which drives the membrane at a reference resident frequency, a frequency device configured to determine the change in the reference resonant frequency, and a mass determining device configured to determine the mass of a substance based on a change in the reference resonant frequency.

Accordingly, independent claim 1 is clearly allowable and patentable under 35

U.S.C. §112(b). Because independent claim 17 is a method of operation claim of the apparatus defined in claim 1, claim 17 is also allowable. Because claims 2, 3, 5, 7-8, 15, 18, and 22-23 depend from allowable base claims, claims 2, 3, 5, 7-8, 15, 18, and 22-23 are clearly allowable and patentable under 35 U.S.C. §102(b).

The Examiner rejects claims 4-6, and 23 under 35 U.S.C. §102(b) as being anticipated by or, in the alternative under 35 U.S.C. §103(a) as being obvious over White *et al.* As shown above, White *et al.* does not teach, suggest, or disclose each and every element of applicants' independent claims 1 and 17. Because claims 4-6 and 23 depend from allowable base claims, claims 4-6 and 23 are clearly allowable and patentable under 35 U.S.C. §102(b) and 35 U.S.C. §103(a).

The Examiner rejects claims 11, 24 and 25 under 35 U.S.C. §103(a) as being unpatentable over White *et al.* The Examiner further rejects claims 8-10, 18-19, 22 and 26-30 under 35 U.S.C. §103(a) as being unpatentable over White *et al.* in view of Bowers. The Examiner also rejects claim 16 under 35 U.S.C. §103(a) as being unpatentable over White *et al.* in view of Ballato.

As shown above, White *et al.* does not teach, suggest or disclose each and every element of applicants' independent claims 1 and 17. Applicants' independent claims 24 and 25 similarly recite oscillator device configured to output a signal to <u>drive</u> the membrane at a <u>reference resident frequency</u>, a frequency device configured to determine the change in the <u>reference resonant frequency</u>, and a mass determining device configured to determine the mass of a substance based on a change in the <u>reference resonant frequency</u>. Applicants' independent claims 26 and 27 are method claims which both recite in part: "<u>driving</u> the membrane layer at a <u>reference resonant frequency</u>".

Applicants' independent claims 28 and 30 recite in part "an oscillator for driving the membrane layer at a reference resonant frequency".

Therefore, White et al. does not teach, suggest, or disclose each and every element of applicants' invention as recited in applicants' independent claims 1, 17, 24-28 and 30.

Accordingly, independent claims 1, 17, and 24-28 and 30 are clearly allowable and patentable under U.S.C. §103(a). Because dependent claims 8-10, 11, 16, 18-19, 22, and 29 depend from allowable base claims, claims 8-10, 11, 16, 18-19, 22, and 29 are clearly allowable and patentable under 35 U.S.C. §103(a).

Moreover, White *et al.* actually teaches away from the applicants' claimed oscillator for driving a membrane at a reference resident frequency, a frequency detection device for determining the change in reference resident frequency, and a mass determining device for determining the mass of the substance based on the amount of change of the reference resident frequency. As shown above, White *et al.* teaches the use of Lamb-waves: this invention marks a departure from the use of SAW or Rayleigh waves in ultrasonic sensors and employs instead Lamb-waves, which are also known as plate-mode waves (Col. 3, lines 11-14, emphasis added). More proof White *et al.* teaches away from the use of standing waves:

> "As important feature of the present sensor is that the wave velocity of the zeroth-order antisymmetrical Lamb waves in the present propagation medium, is lower than the velocity of sound through most fluids. Therefore, in this mode of propagation, the Lamb waves propagating along the propagation medium or membrane cannot radiate energy into the surrounding fluids. (Col. 5, lines 42-48, emphases added).

Therefore, White *et al.* teaches away from the combination with the Bowers and Ballato.

Accordingly, Examiner rejection of claims 8-10, 16, 18-19, 22, and 26-30 under 35 U.S.C. §103(a) should be withdrawn.

The Examiner rejects claims 1, 7-8, 15, 17-18, and 22-23 under 35 U.S.C. §102(e) and (b) as being anticipated by Takeuchi *et al.* The Examiner alleges that Takeuchi *et al.* discloses a sensor for measuring the mass of a substance on a diaphragm 56 in Fig. 1. The Examiner states that a "diaphragm is generally synonymous with a membrane." The applicants respectfully disagree with the Examiner that Takeuchi *et al.* discloses each and every element of applicants' independent claims 1, 17, and 22-23. Specifically, Takeuchi *et al.* teaches measuring the change in the resonant frequency of piezoelectric element 55 and relies on the mass of the substance to be sensed and caught by the catching substance applied on diaphragm 56. Clearly, as disclosed in Takeuchi *et al.*, the piezoelectric element 55 is used to measure the change in the resonant frequency and the alleged diaphragm or membrane is used to catch the substance. *See* Col. 10, line 31-35.

In sharp contrast, the applicants' claimed invention as recited in independent claim 1 includes a sensor having a <u>membrane</u> layer for receiving a substance thereon, an oscillator device configured to drive the <u>membrane</u> at a reference frequency, a frequency detection device to determine the change in resonant frequency caused by the presence of the substance <u>on the membrane</u>, and a mass determining device to measure the mass of the substance based on the change in resonant frequency. The claimed membrane layer receives the substance thereon, is driven at a reference resonant frequency, and the frequency detection device determines the change in resonant frequency caused by the presence of a substance on the membrane. There is no need for a separate catching

device or diaphragm and a separate piezoelectric element as taught and disclosed by Takeuchi *et al.*

Accordingly, Takeuchi *et al.* does not disclose each and every element of the applicants' invention, namely sensor having a <u>membrane</u> layer for receiving a substance thereon, an oscillator device configured to drive the <u>membrane</u> at a reference frequency, a frequency detection device to determine the change in resonant frequency caused by the presence of the substance <u>on the membrane</u>.

Accordingly, applicants' independent claim 1 is clearly allowable under 35 U.S.C. §102(e) and (d). Because independent claim 17 is a method of operation claim of the apparatus defined in claim 1, claim 17 is also allowable. Because dependent claims 7-8, 15, 18, and 22-23 depend from allowable base claims, claims 7-8, 15, 18, and 22-23 are clearly allowable and patentable under U.S.C. §102(e) and (d).

The Examiner rejects claim 11 under 35 U.S.C. §103(a) as being unpatentable over Takeuchi *et al.* The Examiner further rejects claims 8-10, 18-19, 22, 26, and 28 being unpatentable over Takeuchi *et al.* in view of Bowers.

As shown above, Takeuchi *et al.* does not disclose each and every element of the applicants' invention as recited in independent claims 1, 17, and 26 and 28. Accordingly, claims 1, 17, 26 and 28 are clearly allowable and patentable under 35 U.S.C. §103(a). Because claims 8-10, 18-19, and 22 depend from allowable base claims, claims 8-10, 18-19, and 22 are allowable and patentable under 35 U.S.C. §103(a).

The Examiner also rejects claim 16 under 35 U.S.C. §103(a) as being unpatentable over Takeuchi *et al.* in view of Ballato. As shown above, Takeuchi *et al.* does not disclose each and every element of the applicants' invention. Therefore the

combination of Takeuchi *et al.* in view of Ballato fails to teach, suggest or disclose each and every element of the applicants' invention as recited in independent claim 1. Accordingly, because claim 16 depends on an allowable base claim, claim 16 is allowable and patentable under 35 U.S.C. §103(a).

Each of the Examiner's rejections has been addressed or traversed. Accordingly, it is respectfully submitted that the application is in condition for allowance. Early and favorable action is respectfully requested.

If for any reason this Response is found to be incomplete, or if at any time it appears that a telephone conference with counsel would help advance prosecution, please telephone the undersigned or his associates, collect in Waltham, Massachusetts, at (781) 890-5678.

Respectfully submitted,

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MARKED UP CLAIMS

23. (Three times amended) The apparatus of claim 1 wherein said mass determining device measures the change in mass of a substance in the range of about 100 picogram/mm^2 to 100,000 picogram/mm^2.